To:

From: William Pellico, PIP Leader

Bob Zwaska: PIP Deputy Leader, Fernanda G. Garcia: PIP Linac Manager, Keith Gollwitzer: PIP Booster Manager, Kenneth Domann: PIP Planning Controls

Subject: Proton Improvement Plan

Project Quarterly Summary FY13 Q2

Report #4 Apr 01, 2013

Project Milestones

PIP had a limited number of milestones planned for FY13 Q2. Table one below gives the only high level milestone schedule for this quarter.

Table 1: PIP Level 0, 1, 2 Milestones - Summary for 2nd FY13 Quarter

WBS	Task	Level	Date	Milestone	Status
1.2.3.2	Dampers	2	Mar-13	Install Longitudinal damper	Late

The longitudinal damper effort is underway, details are provided in the WBS section below, but delays due to labor constraints during the NoVA shutdown impacted this WBS. Current analog longitudinal system will be used for startup while development continues on the new digital version.

L3 milestones: Linac had three L3 milestones this quarter. Two instrumentation milestones, both milestones were completed on time. With these accomplished, it means that the first Linac WBS (WBS 1.1.3) will be closed out. Booster had one level L3 milestones scheduled for this quarter which was met.

The chart used in the previous FY13Q1 report used milestones generated from the original PIP design handbook (DHB). However, an effort to update the RLS has been underway along with milestone tracking being based upon the current schedule. The RLS update is nearly complete and will be used to update the PIP DHB.

PIP Highlights by WBS Section

WBS 1.1 Linac

The vulnerabilities associated with the LINAC are the 200 MHz accelerating system, including power amplifier tubes and other associated systems such as the modulator; utilities for power distribution and vacuum systems; better need for reliable instrumentation along the Linac to improve beam transport and realistic machine model supported by real beam measurements. There are four largest elements of WBS Level 2 in Linac which are further subdivided at Level 3.

WBS 1.1.1 200 MHz RF Power System

The 200 MHz RF Power System represents approximately 40% of the total scope of the PIP project. There are 3 level 4 elements which will be described below.

WBS 1.1.1.1 High Level RF

This task continued to be on hold during FY13 Q2 due to unknown funding availability. In the meantime, a new quote was asked from CPI where more phases were added to the project so that the team could explore different funding paths by carving out funding from other PIP tasks within FY13 budget.

WBS 1.1.1.2 Linac Modulator

Both the Fermilab EE Support Department and the SLAC Electrodynamics Department are modeling and building components for a Marx modulator to replace the present Linac Modulator. During FY13Q2, EE Support has tested the individual switches for both switching transient and short circuit response, which passed the design criteria. The firing cards for the IGBT switches where also designed and built. Hardware was purchased to build a total of nine Marx stages and construction of these stages has commenced, with plans on testing these stages next. During the same time, the other SLAC design, based on existing Marx ILC modulator, has modified four Marx cells to create both main and vernier cells for testing. These cells where tested for two of the most stringent requirements of the modulator specification, ripple and slew rate, and where close to the expected values. This data is being used to refine the modulator simulation to more accurately represent operation of a complete system. The next stages for the SLAC design that could be perused would be modeling the learning control system to define the optimal integration strategy and continue the hardware development and component validation needed to build the modulator.

WBS 1.1.1.3 7835 Procurement

Currently waiting the receipt of the tube purchased in FY12/Q4 period.

WBS 1.1.2 Accelerator Physics

WBS 1.1.2.1 Simulations and Studies

During this period an extensive review of PARMILA code history and versions was done. With this research it was confirmed that the latest PARMILA version does not have dipole corrector elements and therefore cannot be used for orbit analysis and corrections. A plausible solution would be to use an old version of PARMILA which still has both steering dipole magnets in drift-tubes for an off-line model fitting and perform tracking with TraceWin. This would be the basic configuration for off/on-line modeling mechanism for FNAL Linac.

The original design work for FNAL Linac is dispersed and when information is found it is presented with obsolete codes. Only as hard-copy format, the original MESSYMESH table that was used to fabricate the drift-tubes dimension was recovered during this research effort. The FNAL DTL & BNL tank geometries are the same, so by also searching for BNL Linac design papers it was possible to acquire more technical details vital to reconstruct FNAL DTL geometry more accurately. At the end of this quarter an initial written report of these findings began with the plan to apply all this historical information to a new DTL PARMILA input file. Unfortunately this effort will be put on a hold as , once again, the L4 manager reaches the end of his contract and it appears there will be no more funding to extend his stay.

WBS 1.1.2.2 *Not Used*

Some WBS numbering is nonconsecutive at lower levels because of account closings and rearrangements after financial codes were initially established during the period of setting up PIP.

WBS 1.1.2.3 Linac Notch Creation

There has been activity of three fronts for the laser notcher: 1) the optical pulse generation and fiber amplifier characterization, 2) the beam shaping and transport, and 3) the vacuum assembly which holds the zig-zag mirrors and the optical view ports. Good progress is being made on all three fronts. Operation of the optical pulse generator has been verified with the borrowed pulse generator, creating a continuous 200 MHz, 1.25 ns laser pulse train. With this, the team measured extinction level of the modulator close to the 30 dB reported on the test data sheet. Start commissioning of the fiber pre-amp and first fiber amp. Initiate the characterization of the laser into free space to measure its profile for coupling to the beam shaping optics. The new anamorphic prism allows us to create a very narrow horizontally and tall vertically uniform intensity laser pulse (1mm H x 6-10 mm V). Testing of the beam shaping optics with a green 523 laser continues. Great progress has been made in the design of the vacuum interface which holds the optical cavity.

WBS 1.1.3 Instrumentation

WBS 1.1.3.1 Beam Position Monitors

Complete installation and commissioning of the new BPM readout modules. A total of 66 modules were installed and beam commissioning was performed over the course of this quarter. Various problems were encountered and addressed. Some were simple problems such as forgetting to save registers, loose connections and NIM power supply failure. A more difficult problem is the 805 MHz input signal. When the input signal goes away, the FPGA enters into an undefined state and the crate needs to be rebooted. This occurrence is more severe at the 400 MeV region which receives the reference frequency from a different location compared to the Linac BPM crates. A work around has been developed by the design engineer by the end of this quarter. Nevertheless, the Linac BPM module upgrade is complete.

Figure 1 A new Linac digital BPM crate

This fulfills a Level 3 milestone on time and marks the first Linac WBS Level 3 completion within PIP.

WBS 1.1.4 *Not Used*

Some WBS numbering is nonconsecutive at lower levels because of account closings and rearrangements after financial codes were initially established during the period of setting up PIP.

WBS 1.1.5 Utilities

The Linac Utilities, such as power distribution and vacuum systems are composed of mostly 40 year-old equipment beyond its practical service life. There are two Level 4 elements in this WBS.

WBS 1.1.5.1 Power Distribution

L1 Substation:

During this quarter work has been done on the substation PROFIBUS network that we will use for a SCADA system. The devices are now communicating, but work continues on making the code manageable to work on given that it will be looking at hundreds of data values at any given time. This is simply a matter of figuring out how to read data blocks all at once rather than an individual value each time. Once this complexity is figured out the programming of the devices should be straight forward and quick.

Hatch work: All the required approvals have been received from FESS to proceed with the hatch installation. A thumbnail schedule with necessary tasks were formulate that needs to complete prior the hatch installation, such as the relocation of some electrical conduits, The formal PO for the hatch has not been placed yet, but we expect to move forward with that purchase in the very near future. After the electrical work is done we will begin work on removing some of the lead paint on the cross beam that will need to be removed. After that it will be in the hands of the T&M contractors. We expect the hatch to be installed prior to the startup of the complex on June 1st. We are considering moving the LINAC substation downstairs at the time of the hatch install to make the actual install of the substation less time consuming.

WBS 1.1.5.2 *Not Used*

Some numbering is nonconsecutive at lower levels because of account closings and rearrangements after financial codes were initially established.

WBS 1.1.5.3 Vacuum System

The 400 MeV beam valves were delivered early in the year. However, these valves will be installed in the tunnel during small shutdowns as Linac has been operational since middle of FY13 Q2.

WBS 1.2 Booster

Part of the PIP effort for the Booster Accelerator is to address the increase proton beam flux that will be demanded by the Fermilab program in the upcoming years. The increased flux will be achieved by providing beam on more/all of the Booster cycles; certain equipment will increase from an average 7.5 Hz to 15Hz. Overheating of old components is a major concern; several Booster PIP tasks are to upgrade/refurbish equipment to run at 15 Hz.

The aging original equipment and infrastructure of the Booster are vulnerable due to obsolescence and increase wear due to the increase of flux. Some of the PIP effort is to replace these possible reliability problems.

WBS 1.2.1 RF

WBS 1.2.1.1 Anode Supply

The design work, to be based upon the Main Injector anode supplies, will be done when manpower becomes available in FY13. The engineering is expected to start during the third quarter.

WBS 1.2.1.2 Bias Supply

The delivery of the heat sinks, silicon-controlled rectifiers (SCRs) and water-cooled transformers have begun during the second quarter. Work on the heat sinks will commence soon. The retrofit of the first bias supply will hopefully begin when manpower becomes available late in the third quarter.

WBS 1.2.1.3- *Not Used*

Some WBS numbering is nonconsecutive at lower levels because of account closings and rearrangements after financial codes were initially established during the period of setting up PIP.

WBS 1.2.1.4 Cavity Test Stand

The desired RF equipment from the Tevatron is not available to power the test stand. Due to the lack of funding available to purchase new power supplies, availability of personnel and that the cavity test stand would arrive too late to alleviate conflict in using the existing test stand, the cavity test stand task will not be done.

WBS 1.2.1.5 Cavity and Tuners Refurbishment

The refurbishment of the fifth cavity tuner set was done during this quarter. The time it takes to refurbish and test each set has decreased with the average of the last three sets taking a little more than ten weeks. With each refurbishment, we are learning how to make the process better.

Figure 2 A cavity tuner - showing RF fingers

However, the second cavity tuner set has developed an RF leak. This will require the set to be removed from service, investigation of the RF leak, taking the set apart, fixing the problem and then reassembling followed by certification. Preliminary in-situ investigation points to the outer flange between a tuner and cavity not being a good RF connection. While the set is apart, the inner flange will be reworked (same as the most recent refurbishments). This additional reworking of the second cavity tuner set requires that refurbishment of the current cavity tuner set be interrupted for two to four weeks. There are indications that the first cavity tuner set refurbished may also have a small RF leak.

During a recent refurbishment, the outer flanges were identified as possible problems. The refurbishment procedure has been amended to check-out/rework these flanges whereas before the flange was inspect and only worked upon if the cavity tuner set could not be certified at high gradient at 15 Hz.

WBS 1.2.1.6 New Tuners

Previously, a high power test stand for ferrite cores showed that one of four different core sets (two different permeabilities from two vendors) was acceptable. The acceptable core samples have been implemented into a tuner and been certified. A purchase order for one set ferrite cores was done; delivery of these new cores occurred this quarter. However, only four of the nearly sixty cores passed our high power test. The vendor made several batches of these ferrite cores and the cores that passed came from the same batch. The vendor believes that the chemistry/method of this particular batch is understood and is making new set of cores according to this recipe. The vendor also believes that they can produce the high permeability ferrite cores; a small order of five cores is being done. The two sets of ferrite cores will be tested (and hopefully certified) in the third quarter. Additional material to construct several tuners has been purchased.

WBS 1.2.1.7 New Cavities

Comparison of a model developed for the current Booster RF cavities and the temperature measurements taken as part of the refurbishment task continues.

WBS 1.2.1.8 Cavity 1013

This low priority task requires the same manpower as the refurbishment task; discussions are on-going to locate manpower to complete this cavity. Some resources were found for a short period and work has been done to align different components of this cavity being made of previously rejected cavity parts from the 1970's.

WBS 1.2.2 Accelerator Physics

WBS 1.2.2.1 Simulations and Studies

Studies were done before the shutdown began. The main person doing the studies and analyses has left. The person was able to visit for several weeks at the end of this quarter and able to train/work with two individuals identified to be the main and secondary Booster optics people.

Since the Booster is operational, work is on-going to smooth the orbit to an ideal orbit (see WBS 1.2.2.2) and measure the optics.

WBS 1.2.2.2 Alignment and Aperture

Part of the study period prior to the shutdown was devoted to moving a magnet and re-measuring the local aperture. The increase in aperture seen is in agreement with the expected predictions. A second magnet move was done at the conclusion of the shutdown during this quarter. Measurements of the aperture were done after the magnet move as well as in regions where the Booster machine was worked upon during the shutdown. The magnet move has been verified to have increased the aperture. Other areas have been identified where the alignment of components will be done in the near future. The centers of the apertures have been designated as the ideal orbit (see WBS 1.2.2.1).

WBS 1.2.2.3 Booster Notcher

All work associated with the notcher absorber in the tunnel was completed early this quarter. The system has been roughly timed in and will be fully commissioned in the third quarter. Procurement of parts for upgraded notcher kickers and associated power systems continues.

Figure 3 Booster Absorber system installed

WBS 1.2.2.4 Booster Cogging

Based upon the current cogging equipment, initial code development for the new magnetic cogging method-system is in progress.

WBS 1.2.2.5 Booster Collimation

The collimation task is to control Booster beam loss after implementing the above notcher and cogging systems.

WBS 1.2.2.6 Radiation Shielding

Beam studies concerning the beam loss profile and measurement of beam loss radiation through penetrations has been done. There are on-going discussions of the study results and simulations. Further beam studies and simulations may occur during the third quarter depending upon the results of the discussions.

WBS 1.2.3 Instrumentation

WBS 1.2.3.1 Beam Position Monitors

Design work for the Booster beam position monitor system will begin after completion of the Linac beam position monitor system.

WBS 1.2.3.2 Dampers

Studies to verify damper design choices were not done prior to the shutdown and had been postponed to the accelerator start-up period and will occur during the third quarter.

WBS 1.2.4 *Not Used*

Some WBS numbering is nonconsecutive at lower levels because of account closings and rearrangements after financial codes were initially established during the period of setting up PIP.

WBS 1.2.5 Utilities

WBS 1.2.5.1 Low Conductivity Water System

The task is done.

WBS 1.2.5.2 Power Distribution

Transformers were purchased and may be installed during the third quarter. The purchase of transformers has occurred earlier than plan due to the result of an inspection of one of the transformers; it was recommended replacing the transformer before running the Fermilab physics program.

WBS 1.2.5.3 Vacuum System

Vacuum equipment was purchased and is arrived this quarter. The aged components will be replaced as opportunities present themselves with downtime of the Booster.

WBS 1.2.7 Solid State Upgrade

The Booster RF solid state upgrade has been going on piecemeal for several years with purchasing of enough components to assemble the main elements of the solid state system: power amplifier, driver module and modulator for several stations. With the Proton Improvement Plan, we have been able to buy components in quantities. The East gallery of the Booster had been previously upgraded in FY12.

The West Gallery upgrade completed early this quarter and prior to the start-up of the Booster. Spares of the three main elements were also assembled during this quarter.

PIP Budget – Costs and Obligations Updates (FY13 Q2)

The previous quarterly report mentioned concern over FY12 carry over for several items. The decision has been made by division management that PIP can now use these funds as originally planned. The carryover is currently reflected in both the OBL and RIP. These were not shown in the previous report because of their undetermined status. Notwithstanding the carryover, the spending for FY13 Q2 has been tracking the schedule. However, tasks with significant cost and labor, such as new tuners, new Booster cavity and 201 MHz Klystron, will likely need to have schedule modifications in the outlying quarters. These items have experienced either vendor or budget issues as discussed in their respective WBS summary above.

Table 2 Summary of PIP budget at the end of FY13 Q2

FY13 PIP (K$)	OBL BUDGET	YTD OBL	RIP	BUDGET BAL
M&S	3,860.0	1,042.8	1,409.9	1,407.3
Labor	5,052.0	3,199.9		1,852.1
FY13 Total	8,912.0	4,242.7	1,409.9	3,259.4